CATHODE-RAY OSCILLOGRAPH

STOCK No. 158

Manufactured by

RCA Manufacturing Company, Inc.

Camden, N. J., U. S. A.

"A SERVICE OF THE RADIO CORPORATION OF AMERICA"

IB-32012

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INSTRUCTIONS

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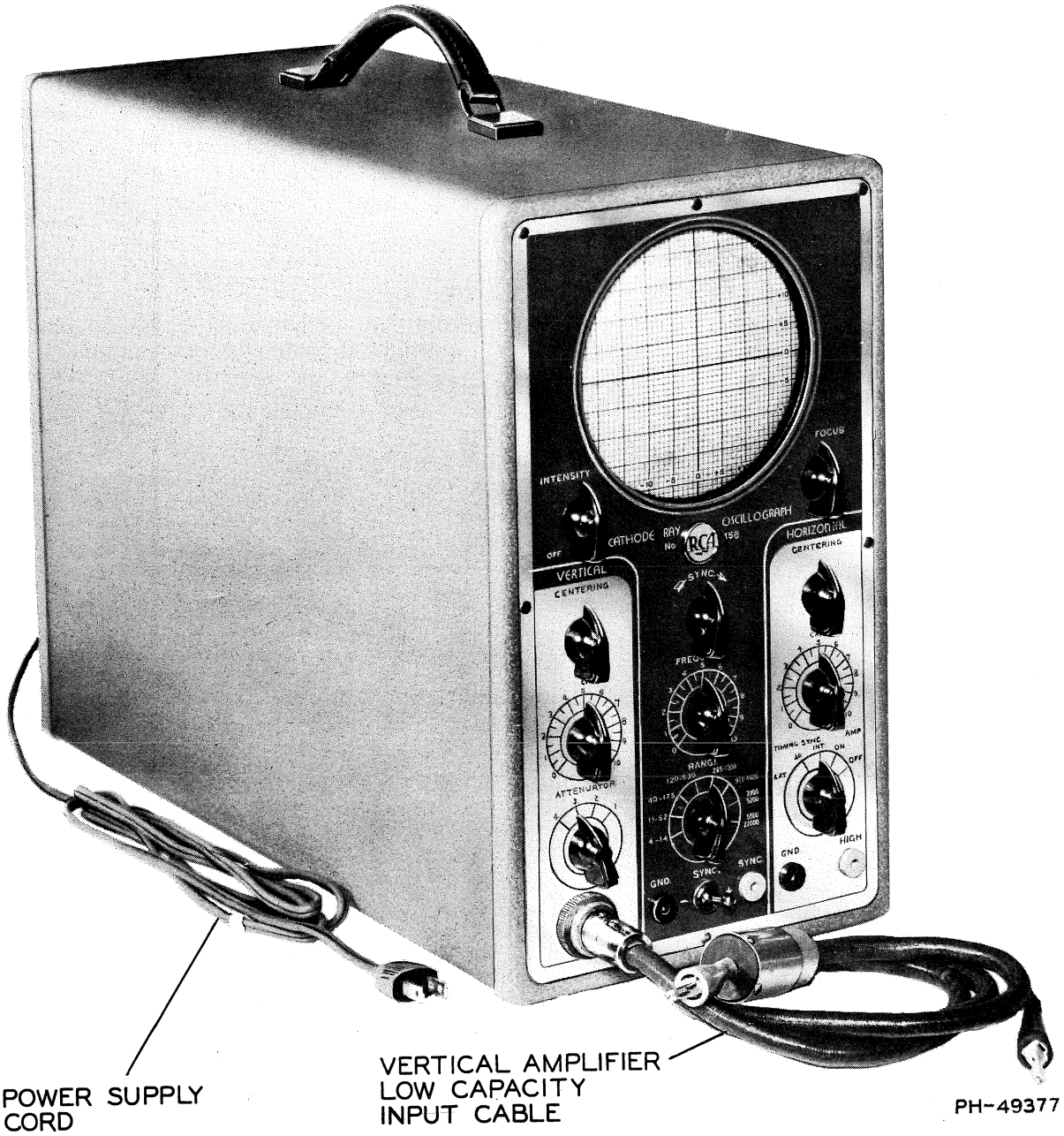
WARNING—A POTENTIAL OF 1500 VOLTS IS PRESENT AT THE CATHODE-RAY TUBE SOCKET AND AT OTHER POINTS ON THE CHASSIS. ALWAYS DISCONNECT THE POWER CORD BEFORE REMOVING THE CHASSIS FROM THE CABINET.



Frontispiece—Stock No. 158 Cathode-Ray Oscillograph

Cathode-Ray Oscillograph

Stock No. 158

TECHNICAL SUMMARY

POWER SUPPLY:

Rating ..... 105-125 volts, 50-60 cycles a-c
Power Consumption ..... 55 watts
Fuse Protection ..... 1 ampere

OPERATING LIMITS:

Deflection Sensitivity at Amplifier without Cable ..... 0.04 v, rms/inch
Deflection Sensitivity at Amplifier with Cable ..... 0.4 v, rms/inch
Input Characteristics:
Vertical Amplifier without Cable 1 megohm, 22 mmfd
Vertical Amplifier with Cable 1.1 megohm, 8 mmfd

Amplifier Frequency Response Range:
Vertical Amplifier Sine Wave .... 5-500 kc
Vertical Amplifier Square Wave 60 cycles—13,000 kc
Horizontal Amplifier Sine Wave 5 cycles— 100 kc
Maximum Signal with Amplifier, 500 volts rms
Frequency Range Timing Axis, 4-22,000 cycles
Maximum d-c at Input Jacks .. 300 volts d-c
Maximum d-c at Input Cable .. 500 volts d-c

TUBE COMPLEMENT:

RCA-6C6 ..... Horizontal Amplifier
RCA-6SJ7 ..... 1st Stage Vertical Amplifier
RCA-1852 ..... 2nd Stage Vertical Amplifier
RCA-884 ..... Saw Tooth Oscillator
RCA-1802 P-1 ..... Cathode Ray Tube
RCA-80 ..... Low Voltage Rectifier
RCA-879 ..... High Voltage Rectifier

OVERALL DIMENSIONS:

Height (including carrying-handle) ..... 14⅜ inches
Width ..... 8 inches
Depth ..... 19½ inches

WEIGHT (net) ..... 30 pounds

DESCRIPTION

The Stock No. 158 Cathode-Ray Oscillograph is a reliable instrument for the observation of electrical circuit phenomena. Although specifically designed for use in servicing television receivers, it is practically unlimited in application, some of its more common uses include the study of wave shapes and transients, measurement of modulation, adjustment of radio receivers and transmitters, determination of peak voltages, and tracing of vacuum-tube characteristics. Its major but not only advantage over older types of visual devices is its freedom from inertia, allowing the observation of very rapid changes of current or voltage without appreciable distortion. The instrument is entirely portable, as shown by the frontispiece illustration, and operates from an a-c source of 105 to 125 volts, 50 to 60 cycles. An integral power-supply unit furnishes all voltages required for operation.

Figure 1 shows the essential units of the instrument in block diagram form.

The primary purpose of these instructions is to give the fundamentals of operation. As the use of cathode-ray apparatus becomes more widespread, many new applications will be found and a thorough understanding of these fundamentals will enable the operator to readily adapt the equipment to his particular use. Since the instrument is built around the cathode-ray tube, the following comprehensive discussion of cathode-ray tubes will serve to explain the operation of the equipment and aid in analysis of the figures which appear on the screen. The operator is urged to read this section thoroughly to insure proper familiarity with the characteristics and performance of the equipment.

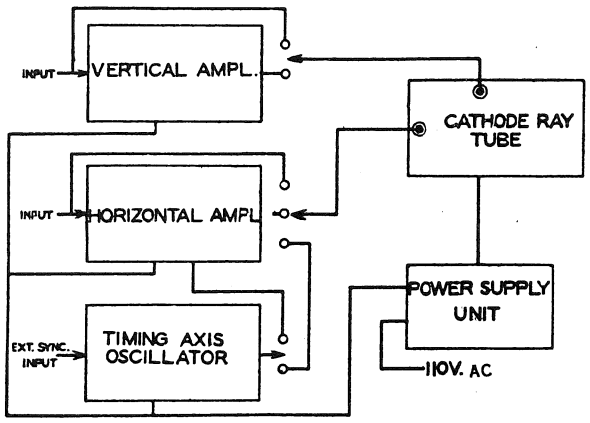


Figure 1—Block Diagram

GENERAL DISCUSSION OF CATHODE-RAY TUBE

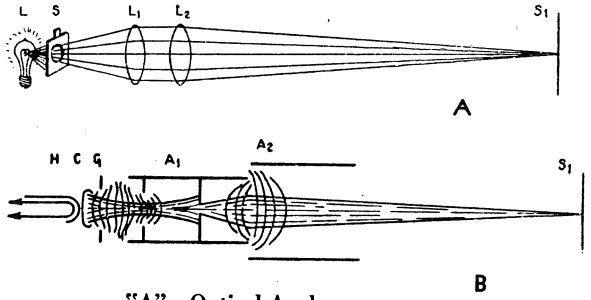
Fundamentally, a cathode-ray tube consists of (1) an electron-beam source, (2) provision for deflecting the beam, (3) provision for focusing the beam on a screen, and (4) a fluorescent screen for visibly indicating the position of the beam.

In the cathode-ray tube the electron source is a substantial indirectly-heated cathode. The cathode control electrode (grid), and focusing electrodes constitute an electron gun, used to project a beam of electrons (Function 1). Two sets of elec-

trostatic plates at right-angles to each other are located within the neck of the bulb to provide for deflection of the electron beam (Function 2). Focusing (Function 3) is accomplished by adjusting the ratio between the voltages on anodes No. 2 and No. 1. This ratio is in the neighborhood of 5:1. In practice, the anode No. 2 voltage is generally held constant and the anode No. 1 voltage is varied, since it is the smaller potential to control. The screen (Function 4) forms one end of the tube. The inside is coated with a material which emits light when struck by the electron beam. The control electrode (grid) constitutes a means of controlling the quantity of electrons admitted into the stream, and thus allows control of spot intensity (also called "brilliancy")—the more negatively the grid is biased, the fewer electrons in the beam, the smaller the spot, and the less the intensity.

The cathode-ray tube requires a high potential between the cathode and anode No. 2. The voltage on anode No. 1 is usually around one fifth of the high voltage, and is made variable to provide a means of focusing. The bias supply to the control electrode (grid) also is made variable to provide a means of controlling the intensity. Since the anode current is usually less than 0.1 milliampere, it is entirely satisfactory to use a rectifier tube in the power supply rated at only a few milliamperes, and to employ only capacity in the filter circuit. With such a small current drain imposed on this power supply, a condenser of 0.5 mfd or more will afford very effective filtering.

The following few paragraphs constitute a very elementary development of cathode-ray tube deflection, and should be omitted by anyone familiar with the basic theory of operation of cathode-ray tubes. Those desiring to make this omission may start at "Study of Lissajou's Figures."



"A"—Optical Analogy
"B"—Three Element Cathode Rays

Figure 2—Focusing Cathode Rays

The "Electron Gun" in the cathode-ray tube may be compared to a simple optical system as shown in Figure 2-A. In this diagram, the light emitted from the lamp, "L," is focused on the screen, "S_1," by means of a double lens system, "L_1," "L_2," and the amount of light is controlled by the shutter, "S," which, when closed, shuts off the light completely. The brilliancy of the image on the screen depends on the size of opening in the shutter, "S," and the candle power or wattage of the lamp, "L." If the candle power of the lamp is fixed (that is, if we select a lamp of a given wattage), then the brilliancy is solely controlled by the shutter, "S." The size or definition of the image on the screen, "S_1" is controlled by adjusting the position of the lenses, "L_1" and "L_2," to the correct distance, which is called focusing. If the position of the lens, "L_2," is fixed, then the focus will depend solely on the adjustment of the position of lens, "L_1." Furthermore, with both lenses, "L_1 and L_2," adjusted correctly, it would be possible to change the focus by actually substituting for the lens, "L_1," various lenses until the one having the correct index of refraction is obtained. This is essentially the method of controlling the focus in the cathode-ray tube.

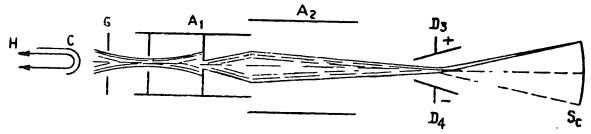


Figure 3—Deflection in One Direction

Figure 2B shows the elements constituting the "electron gun" previously mentioned. "C" is the cathode which radiates electrons when warmed by the heater, "H." The bias voltage of the grid "G," controls the number of electrons allowed to pass through it. The distance from the "gun" at which the electrons converge to a point, or "focus," is determined by the ratio of the voltages on the two anodes, A_1 and A_2. Obviously then, there is a particular ratio of these two voltages which will cause the beam to focus at the screen distance. In practice, the A_2 voltage is usually fixed and the A_1 voltage is made variable through sufficient range to assure that the beam can be focused on the screen.

Figure 3 shows the addition of one pair of deflecting plates, D_3 and D_4, to the previous figure. If these two plates are at the same potential, that is if no voltage difference exists between them, the electron stream is unaffected by their presence. However, if a difference of potential does exist between D_3 and D_4, the electron stream will be deflected toward the plate which is more positive (D_3 in the figure). (A positive charge attracts electrons, which are negative, while a negative charge repels. Both plates therefore bend the electron beam up as shown.)

Assume that a cathode-ray tube has both pairs of deflecting plates connected to a d-c source through potentiometers as shown in Figure 4A. The center position of the "electron spot" on the luminescent screen, with zero voltage on both axes, is shown at B. At C, E_1 has been raised from zero, and it can be seen that the electron beam has been deflected upward and the spot now appears near the top of the screen. At D, E_1 has been returned to zero, and E_2 raised. A horizontal deflection is obtained. The directions of deflection, BC and BD, are essentially at right-angles, due to the physical position of the electrostatic deflecting plates in the cathode-ray tube. At E, both E_1 and E_2 are impressed simultaneously, and with deflections on both axes, the spot has assumed the position resulting from the displacement in the two directions.

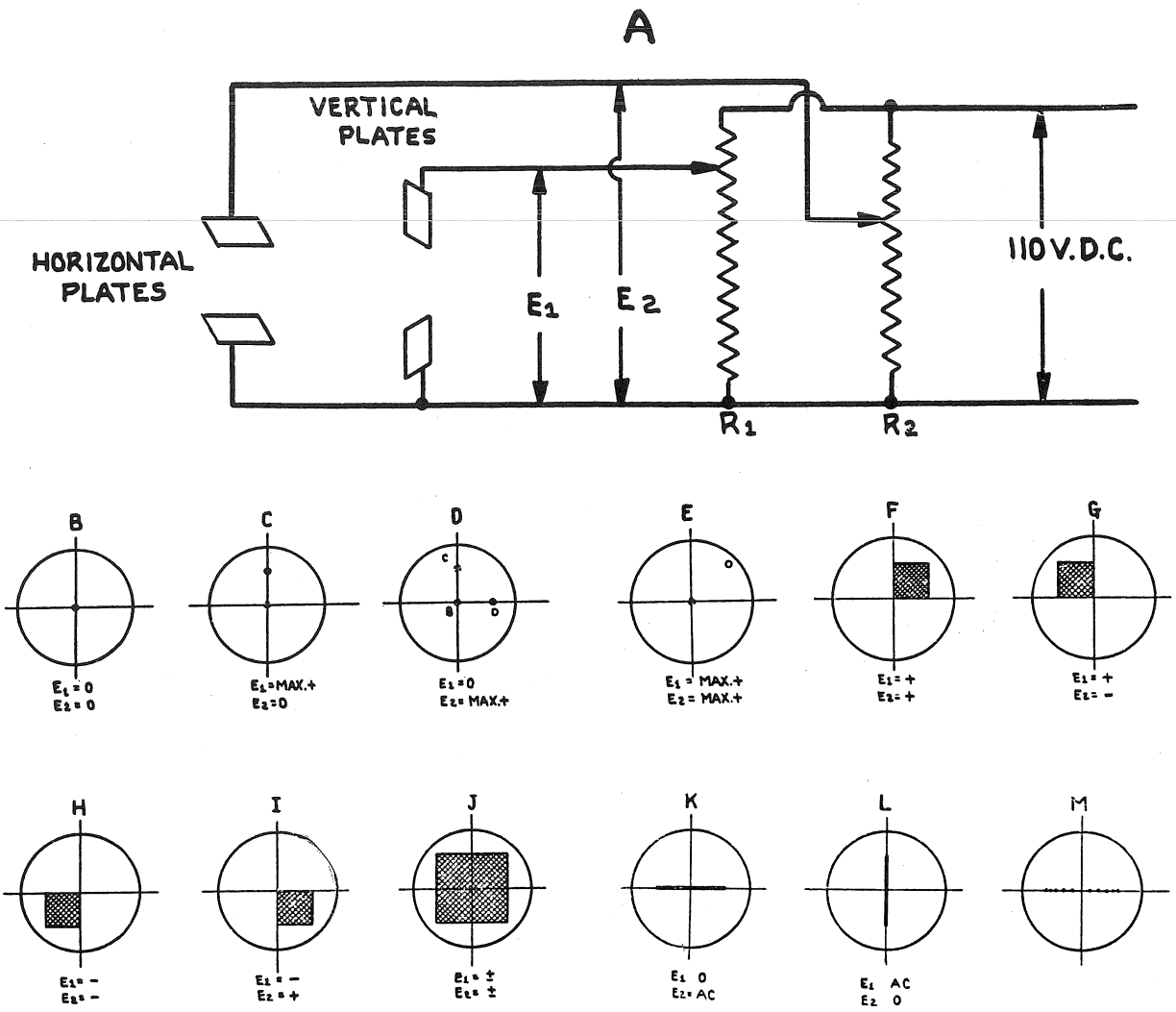


Figure 4—Application of Voltage to Deflecting Plates

It is readily apparent that by proper choice of E_1 and E_2 the spot may be made to assume any position within the shaded area of F. If the supply to R_2 is reversed, the beam will move to the left of center position as the E_2 voltage is increased from zero, and the shaded area of G applies. H and I need no explanation. J shows in shade the area the spot can be made to cover by changing polarity and value of the impressed voltages, E_1 and E_2. Now assume that a 2-cycle a-c voltage is impressed at E_2 ($E_1 = 0$). The spot will be seen to traverse the screen (see M) four times a second, and if the voltage is sinusoidal, the spot will move rapidly in the center of its travel and slowly at each end. If the 2-cycle source is replaced by a higher frequency (20 cycles or more) the spot will no longer be seen, but instead will cause a horizontal line to appear as shown at K. A similar voltage impressed on E_1, with $E_2 = 0$, gives a vertical line as in L. It should be borne in mind that the electron stream is always causing only a small spot to become luminous (assuming correct focus, etc.), but due solely to the illusion of persistence of vision (neglecting screen retentivity), the course of the spot appears as a line or image. A familiar analogy is the motion picture, in which a rapid series of still pictures gives apparent motion.

Study of Lissajou's Figures

When varying voltages are applied to the deflecting plates of a cathode-ray tube, a pattern is obtained on the fluorescent screen. The shape of this pattern depends upon the wave forms of the applied voltages, their frequencies and phase relationships. The following study of these patterns, or Lissajou's figures, is made with particular attention to their development, their use in identifying frequency ratios, and the effect of phase shift.

Figure 5 represents a sine-wave voltage (A) applied to the vertical pair of deflecting plates of a cathode-ray tube and an identical voltage (B) applied to the horizontal deflecting plates. The resulting pattern, shown by (C), is a straight line having a 45-degree slope. The direction of the slope of this line is determined by the phase relation of the two voltages as illustrated in Figures 10A and 10E.* Figure 6 illustrates the case of two identical voltages having the same amplitude but 90 degrees, or 270 degrees, out of phase. In this case, the resulting figure is a circle. If one of the figures is of greater amplitude

*Figures 10 to 16 inclusive, and Figures 26 and 27 adapted from "Frequency Measurements with the Cathode Ray Oscillograph," Frederick J. Rasmussen, A. I. E. E. Transactions, November, 1926, Vol. XLV, Pages 1256–65.

than the other, the resulting figure will be an ellipse as shown by Figure 10C. If the phase relation is such that one voltage leads by 45 degrees, or 315 degrees, the resulting pattern will be that of Figure 10D; if leading by 135 degrees, or 225 degrees, the resulting pattern will be that of 10B. Figures 5 to 9 inclusive, show a graphical method for determining the resulting pattern, where the wave shapes, the relative amplitudes, the phase relation, and the frequencies of the two deflecting voltages are known. By means of the cathode-ray tube, the resultant pattern is traced on the fluorescent screen. Conversely, from this pattern, the frequency and the phase relations of the two deflecting voltages can be determined. Where, in addition, the wave form is known for one of the deflecting voltages, the wave form of the other can readily be obtained by graphical analysis.

Figures 5, 6, and 10A to 10E are for a 1:1 frequency ratio. When a 2:1 frequency ratio of the voltages applied to the deflecting plates is the case, the wave shapes of Figures 10A to 10E become those shown by Figures 10F and 10J.

As the ratio of the frequencies increases, the pattern becomes more complex. In Figure 7, A and B

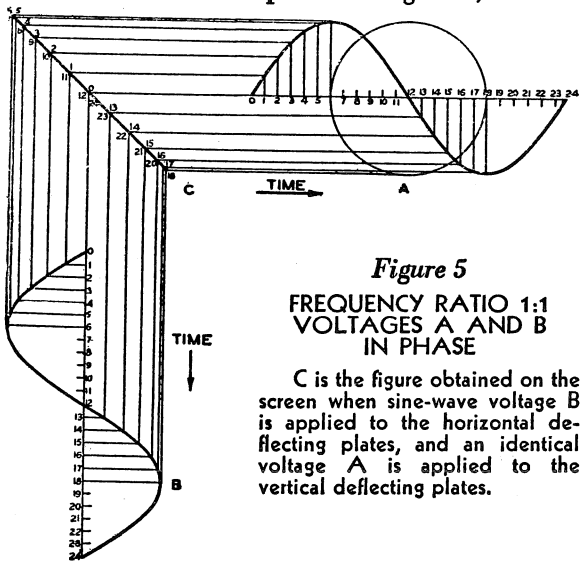


Figure 5

FREQUENCY RATIO 1:1
VOLTAGES A AND B
IN PHASE

C is the figure obtained on the screen when sine-wave voltage B is applied to the horizontal deflecting plates, and an identical voltage A is applied to the vertical deflecting plates.

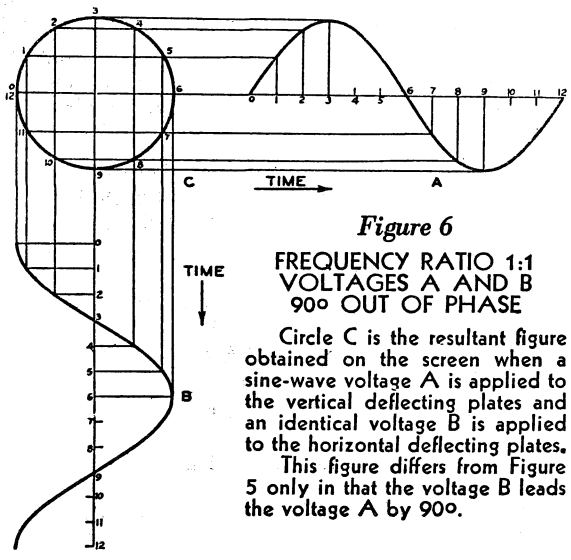


Figure 6

FREQUENCY RATIO 1:1
VOLTAGES A AND B
90° OUT OF PHASE

Circle C is the resultant figure obtained on the screen when a sine-wave voltage A is applied to the vertical deflecting plates and an identical voltage B is applied to the horizontal deflecting plates.

This figure differs from Figure 5 only in that the voltage B leads the voltage A by 90°.

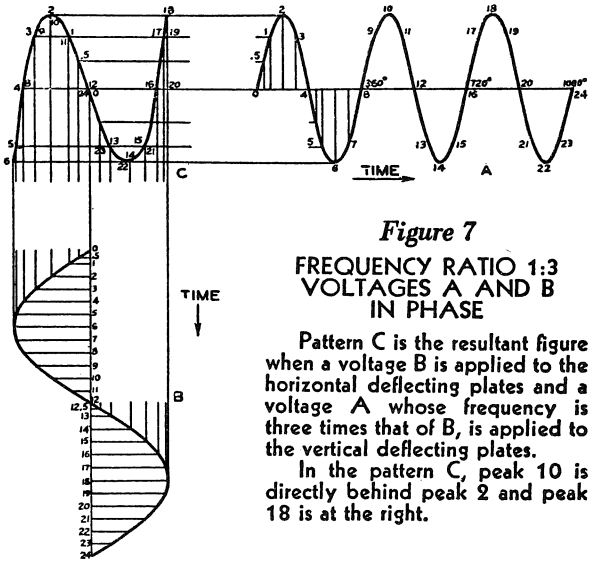


Figure 7

FREQUENCY RATIO 1:3
VOLTAGES A AND B
IN PHASE

Pattern C is the resultant figure when a voltage B is applied to the horizontal deflecting plates and a voltage A whose frequency is three times that of B, is applied to the vertical deflecting plates.

In the pattern C, peak 10 is directly behind peak 2 and peak 18 is at the right.

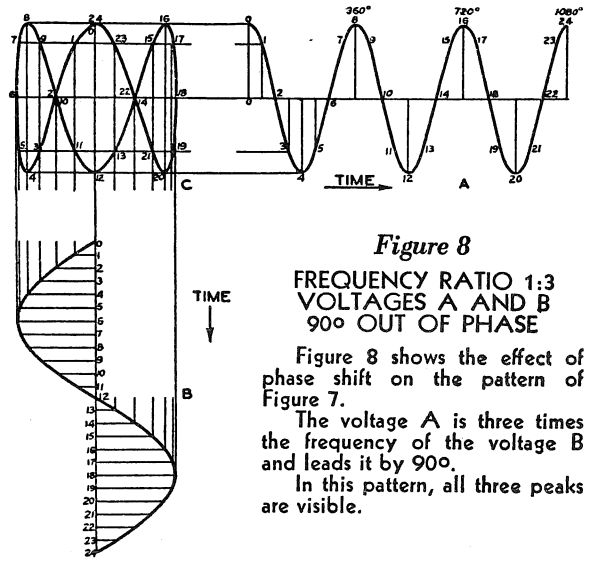


Figure 8

FREQUENCY RATIO 1:3
VOLTAGES A AND B
90° OUT OF PHASE

Figure 8 shows the effect of phase shift on the pattern of Figure 7.

The voltage A is three times the frequency of the voltage B and leads it by 90°.

In this pattern, all three peaks are visible.

are the voltages applied to the deflecting plates. In this case, the frequency of A is three times that of B. The resultant figure (C) shows a 1:3 pattern in which both voltages start in phase. Figure 8 is the same as Figure 7 except that voltage A is started 90 degrees out of phase with respect to voltage B. Figure 9C shows the resultant pattern obtained where B is a saw-tooth wave and A a sine wave. This is of interest because this type of wave form results when a linear timing axis is used. Figures 11, 12, and 13 show patterns of increasing complexity, Figure 13 being an 8:6 pattern.

When the cathode-ray oscillograph is used for calibration purposes, frequency ratios of less than 10:1 can be readily determined by visual inspection of the image. For frequency ratios greater than 10:1, the complexity of the pattern makes visual determination difficult and requires determination by means of photography. In general, the standard frequency selected should be one whose multiples and submultiples will cover the desired range and provide the simplest patterns.

In examining Lissajou's figures, one should consider them as the side view or elevation of a picture traced on a glass cylinder on which the observer may view the wave as it travels around the cylinder. The illusion is clearest when the whole figure rotates slowly. Figure 14 is a simple single-line pattern having a frequency ratio of 6:1. With a base frequency of 60 cycles, this pattern would be the picture for 360 cycles, or with a base frequency of 100 cycles, would be the picture of 600 cycles. The frequency ratio is determined by counting the peaks (six in number) of the waves in the horizontal plane and the

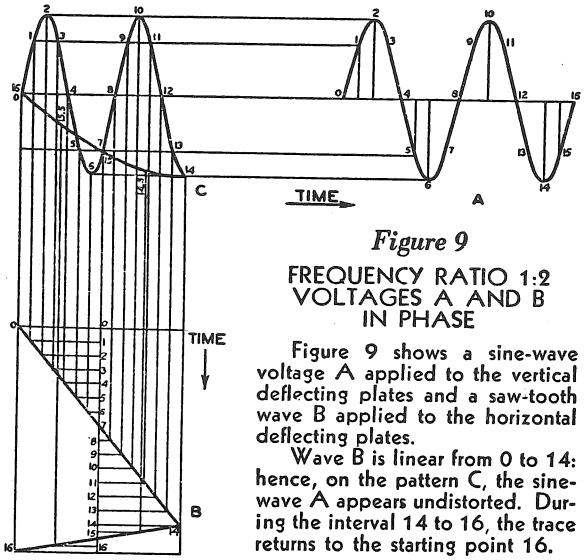


Figure 9

FREQUENCY RATIO 1:2
VOLTAGES A AND B
IN PHASE

Figure 9 shows a sine-wave voltage A applied to the vertical deflecting plates and a saw-tooth wave B applied to the horizontal deflecting plates.

Wave B is linear from 0 to 14: hence, on the pattern C, the sine-wave A appears undistorted. During the interval 14 to 16, the trace returns to the starting point 16.

number of end loops which for this case is one; hence, a frequency ratio of 6:1. In Figure 14, the front tracing has been made heavy and the back tracing light so that the two can be readily distinguished. If the figure were to be shifted slightly, the front and back waves might appear to be one. This condition might mislead the observer to believe that the fre-

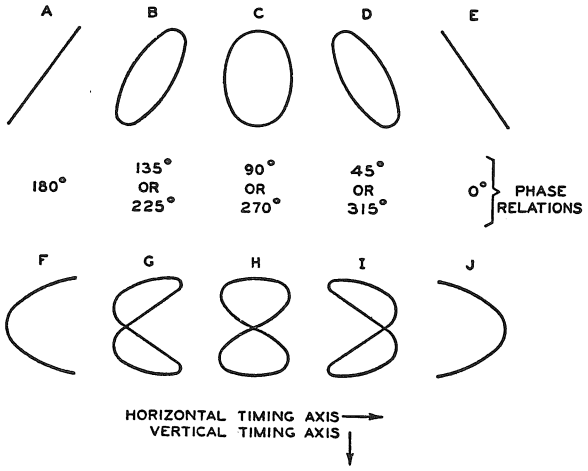
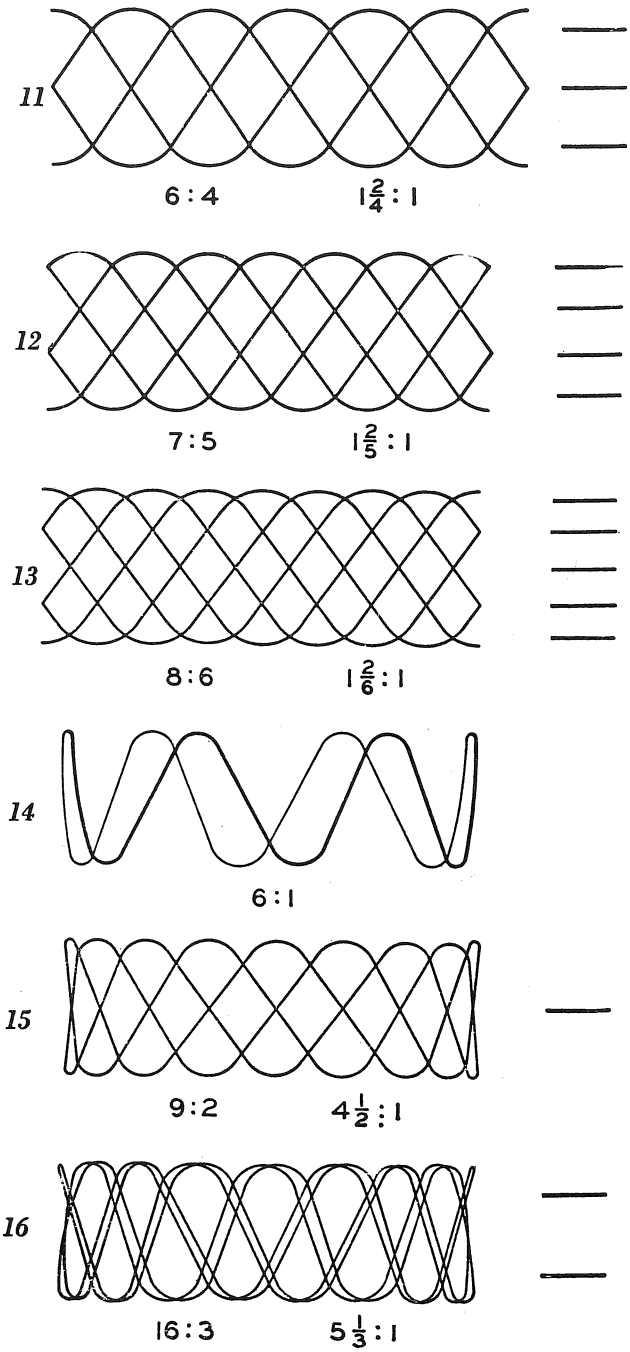


Figure 10

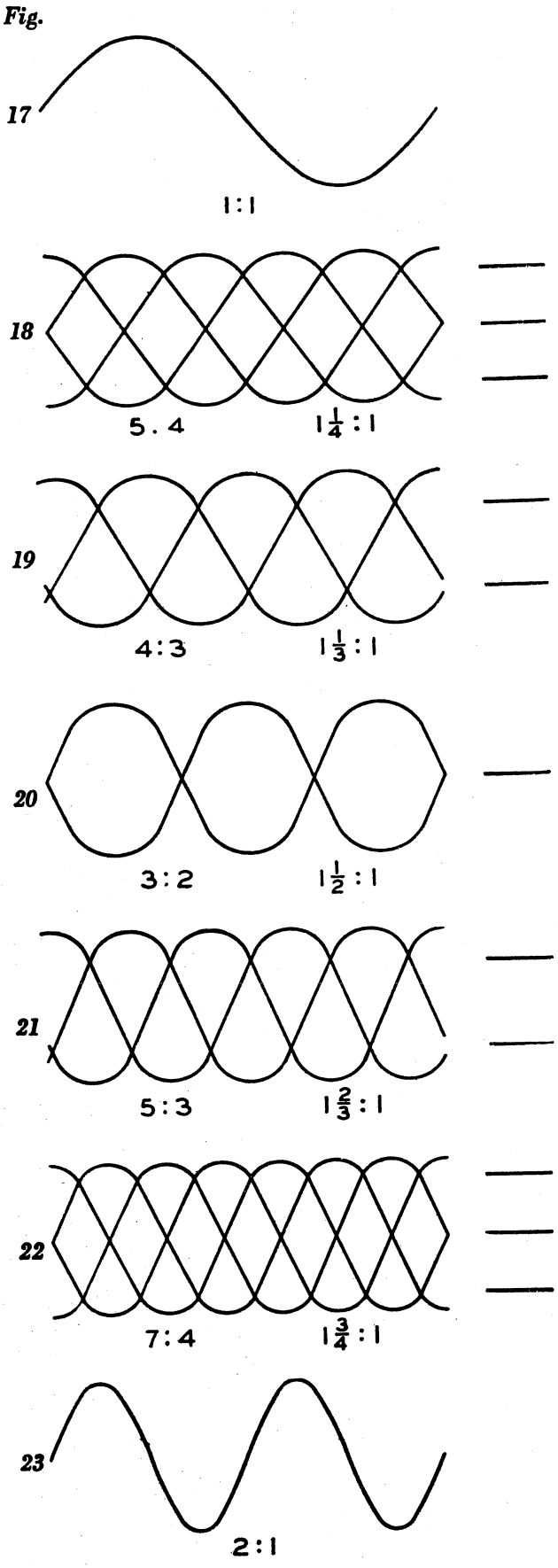
quency ratio was less than 6:1. Adjustment of the unknown frequency so that the pattern rotates very slowly, or stands still with the rear peaks uncovered by the front peaks, will make determination simplest.

It will be observed that the wave form of Figure 14 corresponds to that of Figure 17,* a single-line pattern whose back trace is not visible. Figure 23 shows the simplest 2:1 wave or two-line figure. Figure 15 is a complete two-line figure illustrating a ratio of 9:2, which again, is readily determined by counting the number of peaks along the top of the figure and the number of loops at the end. Figure 16 has 16 peaks and is a three-line pattern, indicating a frequency ratio of 16:3.

Fig.



*Figures 17 to 25, inclusive, adapted from "The Cathode Ray Oscillograph in Radio Research." R. A. Watson Watt. Published by His Majesty's Stationery Office, London, England.



Figures 14, 15, and 16 illustrate patterns as they generally appear on the fluorescent screen. Figures 11 to 13, and 17 to 23 are shown as pictures whose appearance suggests that the pattern has been developed on a plane. They have been shown in this fashion to facilitate study.

An optional method for determination of the frequency ratio is that of comparing the number of peaks on a given figure with the horizontal lines of intersections on the figure instead of with the number of loops at the end of the figure. A study of some of the patterns will make this clear. In Figure 20, there is a single line of intersections along the axes of the figures. It can easily be seen that this is a two-line figure by comparing it with the single line Figures 17 and 23. Figures 16, 19, and 21 having two horizontal lines of intersections, each spaced approximately one-third from the top and bottom, are three-line patterns. In the same manner, the four-line patterns of Figures 11, 18, and 22 are distinguished by three lines of intersection, the five-line pattern of Figure 12 by four lines of intersection, and the six-line pattern of Figure 13 by five lines of intersection with characteristic positions for these lines in each case. Thus, the frequency ratio is also equal to the number of peaks on circumference divided by the term, one + number of horizontal lines of intersection.

Of the patterns from 5 to 23, those of Figures 17, 23 and 7 show simple ratios of 1:1, 2:1, and 3:1. Both these direct multiples and fractional multiples of the base frequency are available to the user of the cathode-ray oscillograph. For example, with a base frequency of 60 cycles, the following tabulation will serve to illustrate the sequence of relatively simple patterns obtained as the frequency of the variable unit is decreased from a 1:1 ratio of frequencies to a 3:1 ratio.

Frequency In Cycles-Sec.	Frequency Ratio* Whole Number	Fractional	Illustrated By Figure
60	1:1	1 :1	17
75	5:4	1¼:1	18
80	4:3	1⅓:1	19
90	3:2	1½:1	20
100	5:3	1⅔:1	21
105	7:4	1¾:1	22
120	2:1	2 :1	23
135	9:4	2¼:1	—
140	7:3	2⅓:1	—
150	5:2	2½:1	—
160	8:3	2⅔:1	—
165	11:4	2¾:1	—
180	3:1	3 :1	7

*The frequency ratio is expressed either as a ratio of two integers, the first of which represents the number of peaks and the second the number of lines in the patterns, or as a ratio of a whole number and a fraction to unity. The denominator of the fraction is equal to the number of lines in the figure.

If the base frequency is 1000 cycles instead of 60, the same ratios hold. Thus, instead of 60 to 180 cycles, the frequencies for these patterns would be those for 1000 to 3000 cycles with intermediate values of 1250, 1333⅓, 1500, 1666⅔, 1750 cycles, 2000 cycles, 2250 cycles, 2333⅓ cycles, 2666⅔ cycles, and 2750 cycles.

When waves having frequency ratios greater than 10:1 are compared, accurate determinations may be difficult with the front and back portions of the

figures in the same horizontal plane. To separate the back and front portions, the figures can be displaced to show either on an ellipse or a circle.

For an ellipse, a phase-splitting device as shown in Figure 28 is employed. Resistance R_1 is connected across one set of deflecting plates and capacitance C is connected across the other pair. With R_2 at maximum resistance, the phase shift is almost 90 degrees. As R_2 is decreased, the phase shift decreases. Figures 24 and 25 show the same single-line pattern and were obtained by adjusting the circuit of Figure 28 for different vertical amplitudes. Figure 26 is a two-line pattern having a frequency ratio of 31:2. The frequency ratio of this figure would be much more difficult to determine without displacement.

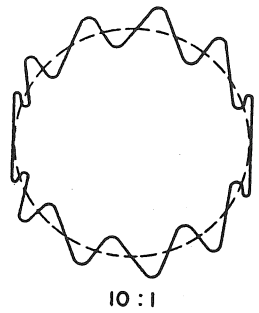


Figure 24

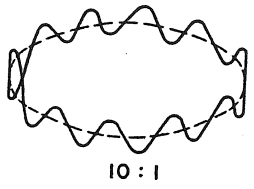


Figure 25

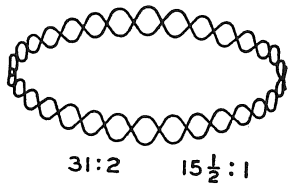


Figure 26

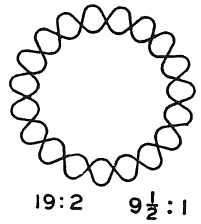


Figure 27

PHASE-SPLITTING CIRCUIT FOR OBTAINING ELLIPTICAL OR CIRCULAR AXIS

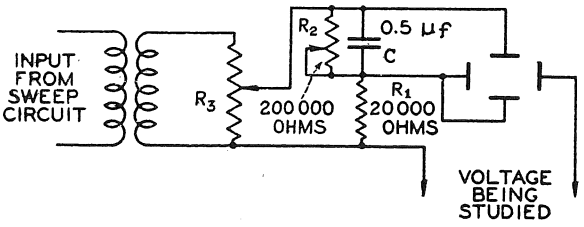


Figure 28

To produce the type of pattern shown in Figure 27, a circular axis is developed using the circuit of Figure 28, with the exception that the voltage under study is introduced in series with anode No. 2. It will be found that the peaks on this type of pattern will be somewhat blurred due to the defocusing effect caused by introduction of the voltage under study into the anode No. 2 circuit. Defocusing can be minimized by keeping this voltage at a low amplitude.

It was pointed out that the patterns of Figures 11 to 13, and 17 to 23 are developed on a plane. The resulting patterns are much simpler than they would be with their normal appearance because the back wave has been removed by spreading it out in the same plane with the front wave. The advantages of this simplified appearance can be obtained in practice by total elimination of the back wave. Where there is some doubt as to the number of lines in a pattern because of the presence of the additional lines of intersections observed in the back wave, this method will be of considerable assistance. Figure 15, for instance, is a two-line pattern, as is shown by the two loops at the end of the figure. However, because of the shift of the figure, the intersection made by the lines of the back wave with the lines of the front wave give it the same appearance as the five-line pattern of Figure 12. To eliminate the back wave, voltage of the same frequency as that used for the spreader, but 90 degrees out of phase, is applied to the control grid of the cathode-ray tube. Adjustment of this voltage will permit weakening the back wave and brightening the front wave, or the total elimination of the back wave.

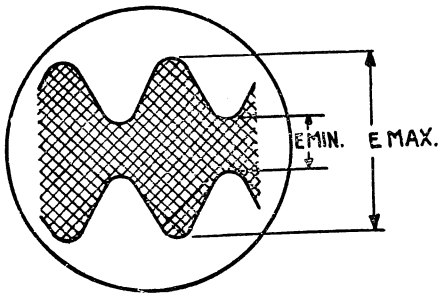
General Applications

The most universal method of employing a cathode-ray tube is to impress the voltage to be observed on the vertical deflecting plates and to impress a voltage varying linearly with time on the horizontal axis. The latter voltage is usually obtained from an oscillator having a "saw-tooth" characteristic (see page 17). The true wave form of the signal on the vertical axis can then be observed without distortion, since none is introduced by the horizontal signal source. The conventional procedure when observing recurrent phenomena is to operate the timing-axis supply at a sub-multiple of the observed frequency, so that several complete cycles will appear on the screen. Since the image will drift across the screen unless the ratio of the two frequencies remains constant and of a certain value, it is usually desirable to synchronize the timing-axis oscillator. For the observation of transient phenomena the timing-axis supply frequency is, of course, not critical and synchronizing is often useless. In some cases, however, it is desirable to synchronize the start of the phenomenon with a timing-axis impulse.

Although use of a linear timing axis is fairly general, there are quite a few applications of the tube

which do not employ one. From the table on page 8, it can be seen that if a sine-wave source of known frequency is impressed on one axis, a variable-frequency source can be impressed on the other axis and calibrated at a number of points other than the known frequency. The phase shift in an electrical device can be observed by impressing the input on one axis and the output on the other axis. If there is 0 or 180-degree phase displacement in the unit, a sloping straight-line image will appear. Refer to Figure 10 (A to E). If the above electrical device happened to be a frequency doubler, Figures 10F to 10J would apply.

Either set of deflecting plates can be used as a peak voltmeter. The impedance can be made very high, and the input capacitance very low, so that the voltmeter will show no discrimination between d-c



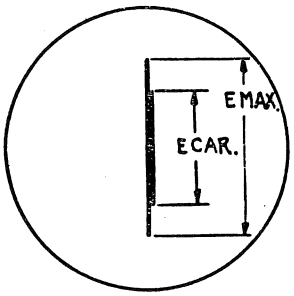
R. F. Modulated at 1000 Cycles
Timing Axis Supply: 500-Cycle Saw-Tooth

$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{EMin.}}{\text{EMax.} + \text{EMin.}} \times 100$$

Figure 29

and reasonably high radio frequencies. Transients can be observed almost as effectively with a sine-wave timing-axis supply as with a linear one, as in this case the supply functions purely as a "spreader."

In order to illustrate the flexibility of such apparatus, a desired measurement will be assumed and several methods of obtaining the unknown quantity outlined. An r-f oscillator is being modulated an unknown amount with a 1000-cycle tone, and it is desired to determine the percentage modulation. One method is to observe the modulated r-f envelope by impressing either a sine-wave or linear supply on the horizontal axis and impressing the modulated r-f signal on the vertical axis. Figure 29 shows this method graphically. Incidentally, if a linear timing axis is used, as shown, the true wave-shape of the envelope will appear, and an appreciable lack of symmetry or other irregularities will be immediately apparent, indicating distortion. If no timing-axis voltage is used, the percentage can be determined as shown at Figure 30. This obviously necessitates removal of modulation. A third method is shown at Figure 31. The 1000-cycle audio voltage which is modulating the r-f signal is impressed on the horizontal axis (modulated r-f remains on vertical). A trapezoid results which allows ready measurement of the peak deflections. Symmetry of modulation can be checked with methods of Figures 29 or 31 by removing modulation from the r-f oscillator and noting whether the carrier height is mid-way between the positive and negative audio heights.

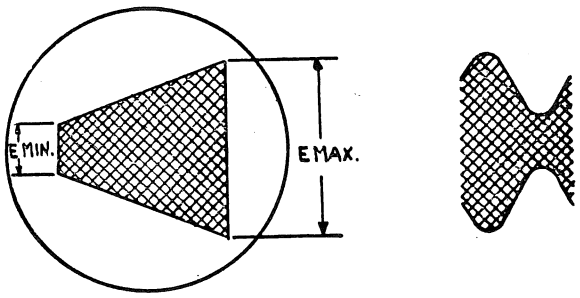


Timing Axis Supply—None

$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{ECar.}}{\text{ECar.}} \times 100$$

Figure 30

Another application of the cathode-ray tube is as a "visual" or curve-tracing device. This consists of an r-f oscillator being varied at an audio rate between two extremes of frequency, a means of displacing the indicating device horizontally in synchronism with the change of radio frequency, and a means of obtaining vertical deflection of the indicating device proportional to the output of the unit whose performance is to be observed. In one method, a variable capacitor is used to "sweep" the frequency of the r-f (test) oscillator continually, and at the same time an impulse generator, driven in synchronism with the "sweep" capacitor varies an oscillator capacitor, providing horizontal displacement of the indicating device in synchronism with the "sweep" capacitor. More recently, electronic frequency modulators requiring no moving parts have become popular. Perhaps the greatest use of such a device is for alignment of the inter-



Timing Axis Supply—The Modulating Signal

$$\text{Percent Modulation} = \frac{\text{EMax.} - \text{EMin.}}{\text{EMax.} + \text{EMin.}} \times 100$$

Figure 31

mediate-frequency stages of superheterodyne receivers. A frequency-response curve of the circuit under test is continually before the aligner, which allows rapid and very accurate adjustment of the

stage in question. The great advantage from such a system is realized when the circuit to be aligned has sufficiently greater than critical coupling to give a flat-topped or double-peaked response. The same result can eventually be obtained by manually plotting a curve each time an adjustment on the unknown is made. However, this latter method is very laborious and requires considerable time.

Alignment of the radio-frequency stages of receivers can be made using the same method discussed above for i-f alignment. The single-frequency source and output meter method may be used, if desired, but from the standpoint of demonstrating the performance of the r-f stages or explaining their operation, the oscillographic method is preferable.

Another type of visual, commonly known as a "universal" type, has as its primary function the measurement of capacity and inductance. Fundamentally, it is the same as the visual described above for aligning i-f stages, but the i-f stage, instead of being the part under test, is permanently incorporated in the equipment. In other words, the output of the r-f oscillator, instead of feeding the grid of an i-f tube, is coupled to a tuned tank circuit which is across the grid circuit of a detector tube. Parts are tested by comparing the resonant frequency of this tank circuit with a part of known characteristics to the resonant frequency with a part of unknown values. (In either case, the part forms a portion of the tank circuit.) The universal visual is chiefly applicable for quantity testing of coils and condensers. Very rapid testing can be done, as there is only the necessity of connecting the part to be tested and observing the position of the curve on the screen. Small fixed condensers have been tested manually as rapidly as 2,000 per hour on equipment of this type, though this is somewhat above average. The visual also has the advantage of affording a test at any radio frequency, so that difficulties from skin effect, distributed capacity and inductance can be greatly reduced by employing a frequency at or near the one the part will be subjected to in use.

In using cathode-ray tubes, the voltage under observation often is not of sufficient value to give the desired amount of deflection and a voltage amplifier must be employed. The amplifier should have an essentially flat output over a sufficient frequency range to avoid appreciable distortion of the observed signal. For ordinary use, it is not objectionable if the amplier is non-linear above the sixth harmonic of the frequency of the observed voltage.

INSTALLATION

Remove the screws at the rear of the case. Withdraw the chassis from the case, feeding the power cable through the hole in the back. Make certain that all tubes are firmly in their sockets and that all grid-cap connections are in place. Unpack the cathode ray tube and install it in its proper mounting and connect the socket, rotating the tube if necessary so that the socket key is located at the top. Replace the chassis in the case and replace the screws at the rear. With the "*Intensity*" control in the extreme counterclockwise *("Off")* position, plug the power-supply cable into an electrical outlet supplying 105-125 volts at at 50-60 cycles. The instrument is then ready for operation.

NOTE: AN INTERLOCK SWITCH, LOCATED AT THE REAR OF THE CHASSIS, OPENS THE POWER CIRCUIT WHEN THE CHASIS IS REMOVED FROM THE CASE. DO NOT ATTEMPT TO OPERATE THE EQUIPMENT WHILE WITHDRAWN FROM THE CASE AS THE HIGH POTENTIALS USED ARE DANGEROUS.

OPERATION

Controls

Refer to the schematic and wiring diagrams for the location of circuit units designated by symbols.

1. "*Intensity*" control (R-41) consists of a potentiometer located in the high side of the high-voltage bleeder and controls the bias on the grid of the cathode-ray tube, which in turn determines the quantity of electrons emanating from the "gun," thus controlling the spot size. The power switch (S2) is attached to this potentiometer. Initial clockwise rotation of this control closes the switch and additional rotation increases the spot size.

2. "*Focus*" control (R-43) is a potentiometer located in the high-voltage bleeder. Its position controls the No. 1 anode voltage, which, with constant voltage on anode No. 2, determines the distance at which the electron beam focuses. In general, for a given "*Intensity*" setting, the "*Focus*" control should be set for maximum distinctness of spot or image.

3. "*Vertical Amplifier*" switch (S-6) is an input attenuator in the grid circuit of the first amplifier stage. The attenuation steps are approximately 1:5. Connection to the input is made through a special cable which may be omitted if higher input capacity is permissible. An increase in sensitivity of approximately 10 to 1 is obtained without the cable. Input connection, in this case, is made to terminal #2 of the input jack.

4. "*Horizontal Amplifier*" switch (S-3) has five positions: The amplifier "*On*" and "*Off*" and three "*Timing*" positions. On all "*Timing*" positions the "saw-tooth" or timing-axis oscillator feeds through an amplifier to the horizontal deflecting plates of the cathode-ray tube. At "*On*," the "*Horizontal*" phone tip jacks are connected through an amplifier to these deflecting plates while at "*Off*," the phone tip jacks are connected

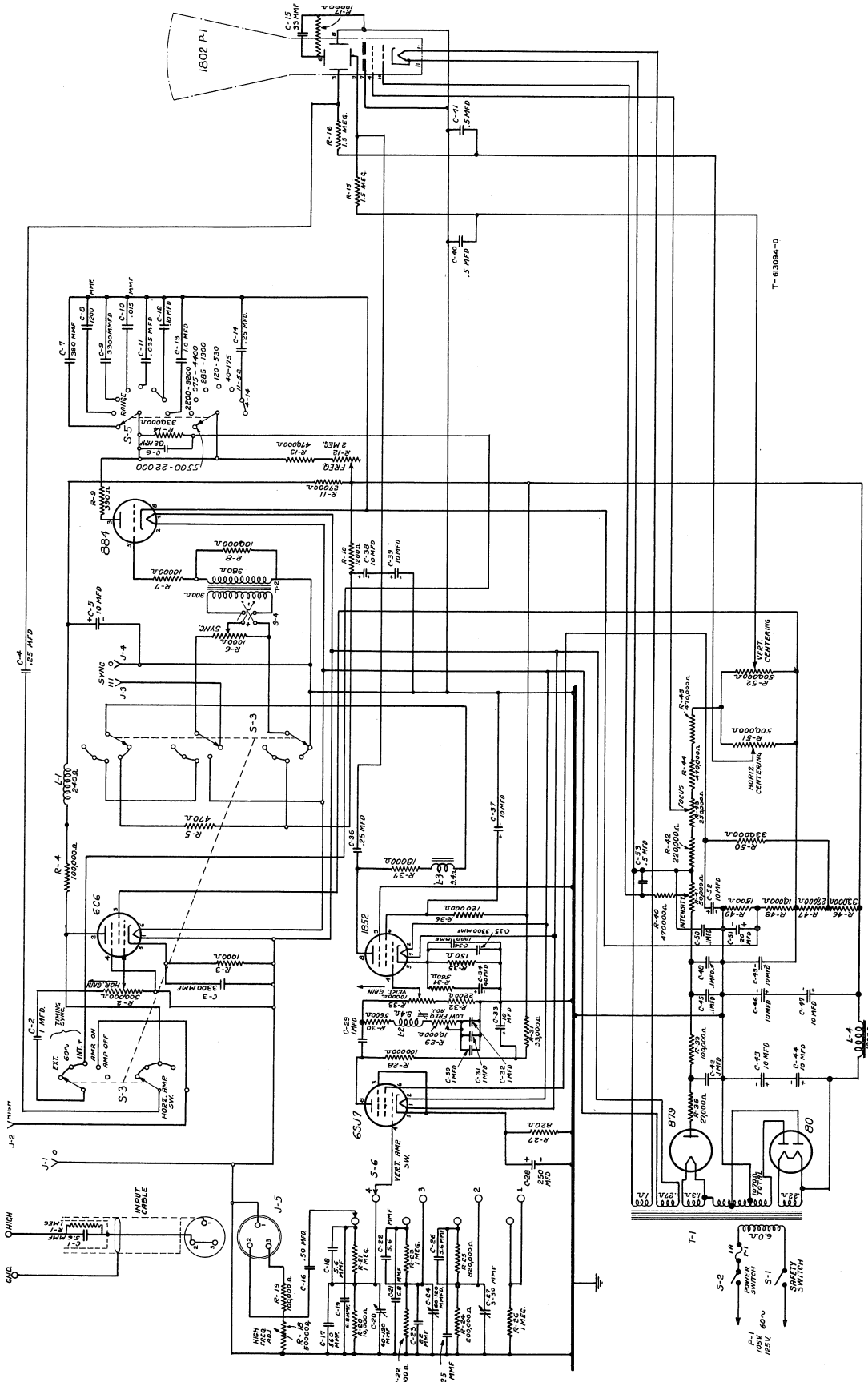


Figure 32—Schematic Circuit Diagram.

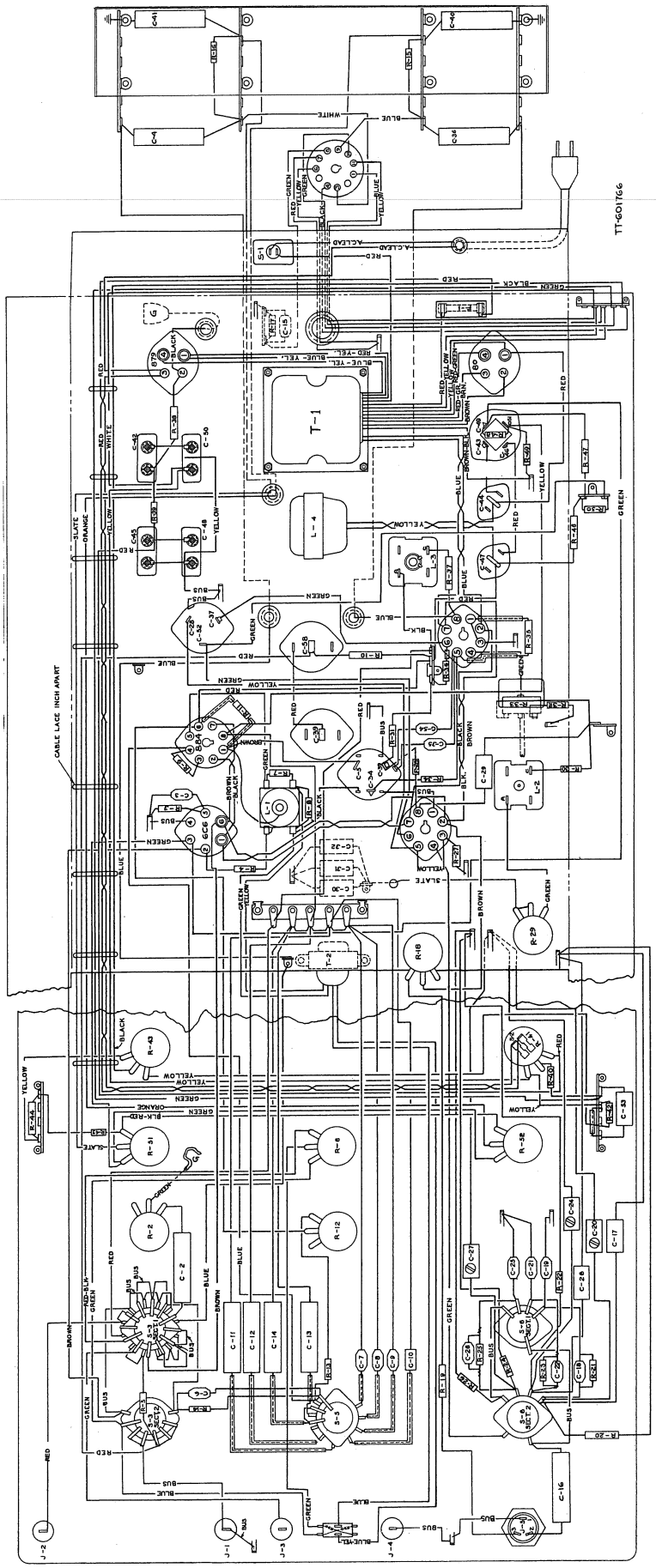


Figure 33—Chassis Wiring Diagram.

straight through to the deflecting plates. In both of the latter two cases, there is a series condenser in the input circuit.

5. *"Vertical Gain"* control (R-33) consists of a potentiometer located in the grid circuit of the 2nd stage of the vertical amplifier. With the *"Vertical Amplifier"* switch set for any given position this potentiometer controls the vertical deflection. By advancing the *"Vertical Amplifier"* switch from a lower to the next largest number the sensitivity is cut approximately 5 to 1.

6. *"Horizontal Gain"* control (R-2) consists of a potentiometer located in the input circuit of the horizontal amplifier. With the *"Horizontal Amplifier"* switch set at *"Timing"* or *"On,"* this potentiometer controls the horizontal deflection. Due to the capacity load on this input potentiometer, when operating on *"Timing"* at the higher audio frequencies, linear sweep will not be obtained at all settings of this control. For best results, the control should be set for maximum linearity.

7. *"Range"* switch (S-5) selects one of eight timing capacitor values. It thus changes the timing-axis oscillator frequency in steps, giving eight ranges approximately as shown on the front panel.

8. *"Freq."* control (R-12) is a rheostat connected in series with the timing condenser. It changes the timing-axis oscillator frequency gradually as it is rotated, and in conjunction with the *"Range"* switch, gives a continuous range between the extremes of frequency.

9. *"Sync."* control (R-6) is a potentiometer used to control the amount of synchronizing voltage fed to the grid of the RCA-884 tube. In general, it should be set as far counter-clockwise as is consistent with a locked image, since over-synchronization results in a poor wave-form produced by the timing-axis oscillator.

10. The *"Sync."* switch provides for a 180-degree phase shift of the image on the screen.

11. *"Horizontal Amplifier"* switch (S-3) has three timing positions, *"Int.,"* *"60,"* and *"Ext."* for synchronization. At *"Int.,"* the voltage drop across resistor R-5 in the plate circuit of the vertical amplifier is fed through the *"Sync."* control and input transformer to the grid of the RCA-884 tube. Thus, the timing-axis oscillator can be synchronized with the signal on the vertical axis at the fundamental frequency or at any sub-multiple, such as ½, 1/3 . . . Synchronization is not effective if it is attempted to operate the timing-axis oscillator at a higher frequency than that of the synchronizing voltage. When set to "60" a portion of the 60 cycle filament voltage is used for synchronization. On *"Ext.,"* the *"Sync."* phone tip jack is connected to the *"Sync."* control. This allows the use of an external source for synchronizing.

12. The two "centering" controls regulate the amount of d-c potential between the two deflecting plates of each pair, and thereby allows adjustment of the position of the spot or image. There is sufficient voltage across these controls to move the spot approximately two inches on the screen. Start with both of these controls adjusted at about mid-position.

13. There are four phone tip jacks provided on the panel. A voltage applied to the *"Horizontal"* jacks, with the horizontal amplifier switch S-3 in the *"On"* position, will result in a horizontal deflection of the spot. The *"Sync."* phone tip jack is used for external synchronization of the saw tooth oscillator. The *"Gnd."* jacks are connected to the chassis. A switch labeled *"Sync."* controls the synchronization of the saw tooth oscillator with the source on either positive or negative impulses.

Applications

The following procedures are included in order to familiarize the operator with the operations and connections involved in particular applications. All applications of the equipment are not described, but analysis of any other problem will show wherein it is similar to or differs from those given, enabling the operator to work out his own sequence of operation.

As has been pointed out previously, most applications of this instrument are performed with the output of the unit under test connected to the vertical plates of the cathode-ray tube, and the wave shape studied by application of known constants on the horizontal plates of the tube. Before any measurements are attempted, the operator is urged to go through the following procedure in order to familiarize himself with the controls and their location and to get the "feel" of their operation:

1. Connect the power plug to an a-c source of 110/120 volts, 50/60 cycles. Turn the *"Intensity"* control clockwise, causing a spot to appear on the screen, increasing in size as the *"Intensity"* control is advanced further clockwise. The *"Focus"* control should then be adjusted until maximum distinctness of the spot or image occurs. The centering controls should be set about mid-position.

CAUTION. DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME, AS DISCOLORATION OR BURNING OF THE SCREEN WILL RESULT.

With the spot on the screen and with the *"Intensity"* control retarded so that the spot is not too brilliant, adjust the position of the spot to the center of the screen by rotation of the two centering controls. After initial adjustment, these controls will rarely require re-adjustment, unless the cathode-ray tube is replaced.

To turn the equipment off, turn the *"Intensity"* control to its extreme counterclockwise position, until a distinct "snap" is heard.

2. Apply a source of 60-cycle current to the input cable. To adjust the length of the resultant line appearing on the screen, turn the *"Attenuator"* switch to one of its four positions and adjust the *"Gain"* control until the length is as

desired. The line will be as shown in Figure 4L. Application of the same 60-cycle source to the *"Horizontal"* pin jacks with the *"Horizontal Amplifier"* switch *"On"* or *"Off"* will similarly show a horizontal line on the screen, the length of which may be varied (with the *"Horizontal Amplifier"* switch *"On"*) by manipulation of *"Horizontal Gain"* control. See Figure 4K.

3. To expand (2) further, have 60 cycles available at both *"Horizontal"* and *"Vertical"* terminals.

CAUTION. Since all ground or *"Gnd"* pin jacks on the oscillograph are common, it is advisable to use an isolating transformer for one supply, so that there is no common connection between the two.

Apply the horizontal 60-cycle supply to the deflecting plates, preferably through the amplifier and its gain control, then apply the 60-cycle vertical supply through the other amplifier and its gain control. The result will be a straight line. (See Figure 5 and explanation.)

AC VOLTMETER WITH AMPLIFIER—For this application, the characteristics of the unit are as follows: Input resistance—1.1 megohm, input capacity—approximately 8 mmfs; voltage range—approximately 175 volts (higher with external attenuator); calibration—approximately 0.64 peak volts per inch or 0.4 r-m-s volts per inch.

Procedure—Make connections to the Oscillograph and turn controls to the proper positions. Measure or estimate the length of line appearing on the screen in inches (depending on accuracy desired) and multiply by 0.64. This gives the approximate peak value of the unknown voltage. For approximate effective value, if voltage being measured is sinusoidal, divide peak value by 1.4.

Procedure—Make connections and adjust controls. With the *"Vertical Gain"* control in the extreme clockwise position, a line one inch long is obtained on the screen for about 0.64 peak volts input. Intermediate positions of the gain control give different calibrations, of course, and if considerable use is made of this feature, it may be advisable to plot a curve of the inputs required to give a one-inch deflection at various intermediate positions of the gain control. If working at a frequency above 10,000 cycles, it must be remembered that retarding the gain control from maximum impairs the linearity of the amplifier.

A particular application of operation as an a-c voltmeter is in making hum measurements in a power supply unit. In this case, the *"Gnd."* pin jack or cable ground lead *("Vertical")* is connected to the common lead of the filter circuit of the unit under test and the input cable is used to check the a-c ripple present at the various circuit component terminals.

AUDIO QUALITY MEASUREMENTS—Use of the "saw-tooth oscillator" feature of the oscillograph provides a check which cannot be made with an ordinary voltmeter. This is extremely helpful in

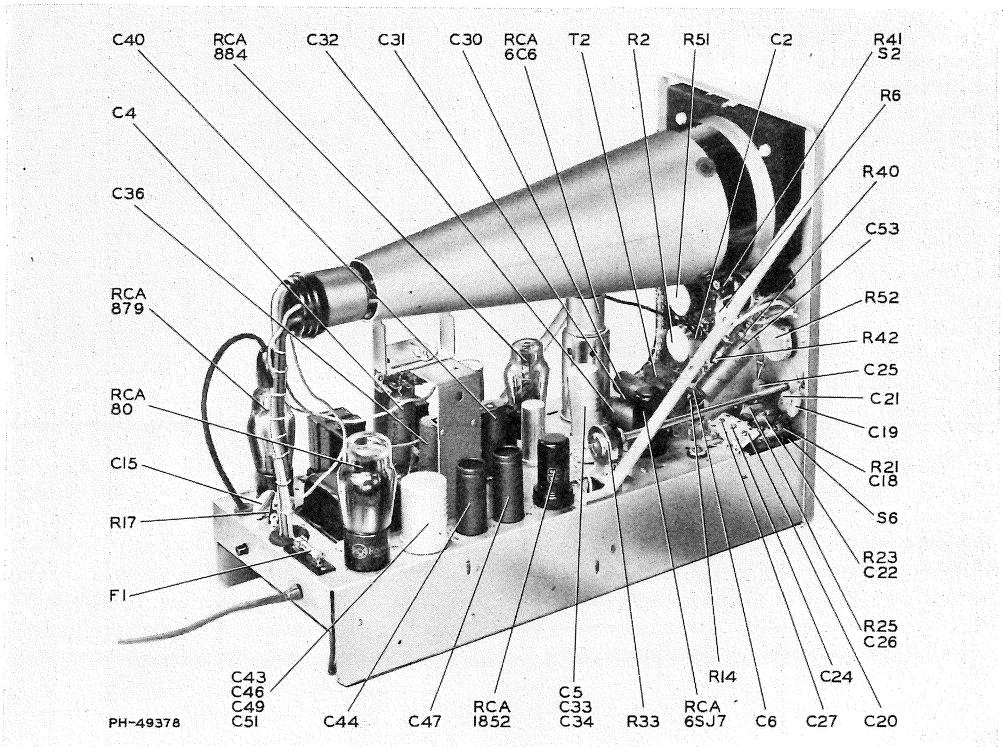


Figure 34—Top View of Chassis

determining the audio quality of a receiver or similar instrument and also in locating causes of audio distortion.

Procedure—Apply the output from a constant frequency record or audio oscillator to the input cable. Turn the "*Range*" switch to that tap giving a range including the frequency of the input signal and adjust the "*Freq.*" control until the saw-tooth oscillator frequency is near that of the input signal. If the two frequencies are identical, one cycle of the input signal will be observed on the screen; if the saw-tooth oscillator frequency is one-half that of the input signal, two cycles of the latter will appear; if one-third, three cycles; etc. Next, connect this constant frequency record or audio oscillator output to the audio input of the unit under test and connect the output of the unit under test to the input cable of the oscillograph. If the resultant wave does not correspond to that obtained when the input was direct to the oscillograph, audio distortion is present.

If it is desired to measure the overall audio fidelity of a receiver, for instance, the procedure is similar to that above except that the voltage modulating an r-f oscillator is fed into the oscillograph, adjusted as above. Then the modulated oscillator is connected to the r-f input terminals of the receiver and the loudspeaker voice coil connected to the oscillograph. Comparison of the two resultant waves will indicate how much distortion occurs in the receiver under test. Observing the quality of the input to the receiver from the test oscillator will also show how much distortion is being fed into the receiver from the test oscillator. This is desirable since it may show that all the distortion present in the receiver output may not be due to the receiver characteristics, but to those of the test oscillator (assuming no distortion from modulation).

MODULATION INDICATOR—(1) One method of measuring the modulation of a transmitter is to place the modulated r-f output of the transmitter into the vertical plates of the cathode-ray tube and the audio input signal to the transmitter on the "*Sync.*" pin jacks.

Procedure—Connect a constant-frequency input to the transmitter and connect a small pickup coil, located near the transmitter tank coil, to the input cable. The pickup on this coil should be from 1.2-10 volts. Connect the "*Sync.*" pin jacks of the oscillograph to the transmitter audio amplifier at a point providing a 2- to 4-volt signal. Set Horizontal Amplifier switch to "*Ext.*" position. Turn the "*Range*" switch to the tap which includes the frequency of the input signal and adjust "*Freq.*" control until the saw-tooth oscillator interlocks with the signal on the vertical plates. Adjustment of the "*Sync.*" control provides control of the voltage from the audio amplifier to the grid of the RCA-884 tube. Adjustment of "*Horizontal Gain*" control varies the horizontal deflection.

(2) Another and somewhat similar method of modulation measurement is to connect the pickup coil to the input cable as before, but connect the audio signal (from the transmitter audio amplifier) to the "*Horizontal*" jacks. Adjust "*Horizontal Gain*" control until desired horizontal deflection is obtained. The percentage modulation can then be readily determined. See Figure 31.

ALIGNMENT OF INTERMEDIATE-FREQUENCY STAGES—When using this instrument with any given receiver specific instruction sheets on that particular receiver should be obtained from your distributor and carefully followed. For alignment of the intermediate-frequency stages of a receiver, it is essential that an auxiliary apparatus be available to sweep the intermediate frequency for which the receiver is designed. The Stock No. 9558 (Type TMV-128-A) Frequency Modulator is designed for this use. It consists of sweep condenser and a synchronizing generator rotated in synchronism by a driving motor. The condenser is arranged to "sweep" the frequency of the r-f input to the receiver (or i-f stages) and the synchronizing generator connects to the "*Sync.*" jack of the oscillograph so as to synchronize the saw-tooth oscillator with the frequency variation of the test oscillator (such as the Stock No. 153) input to the receiver. A switch on the panel of the frequency modulator provides two ranges of capacity for "sweeping" the test oscillator output frequency; on "*Hi*" the range is 20-65 mmfd, and on "*Lo*" the range is 15-35 mmfd. The electronic sweep test oscillator, Stock No. 150, provides a frequency-modulated signal and a synchronizing signal, so that no other frequency modulator is required.

The test oscillator output should be coupled to the grid of the tube preceding the i-f stage under alignment. It is essential that this connection be made without altering any of the operating characteristics of this stage. If the grid of the tube to which connection is to be made is at zero d-c potential with respect to ground, connect the oscillator to the grid of the tube and disconnect the lead normally on the grid, the low side of the test oscillator output returning to chassis ground. If the grid is not at zero d-c potential with respect to ground, connect the high side of the oscillator to the grid (disconnecting the lead on the grid) and the other side to the "—C" lead for this grid.

The "*Vertical*" input cable of the oscillograph should be connected to the audio output of the second detector. For a diode detector, this connection may be across the volume control alone or across both the volume control and automatic volume control resistor, if this connection is convenient. When the second detector is a triode, tetrode or pentode, resistance-coupled to the first audio stage, the connection to the input cable may be to the plate of the tube, the "*Gnd*" lead being connected to ground. In the case of a triode, tetrode or pentode, transformer- or impedance-coupled to the first audio stage, connect a resistor of approximately 20,000 ohms in series with the

plate of the tube and by-pass the inductance in the plate circuit by a 1.0 mfd or larger capacitor. This changes the impedance of the plate circuit to resistance rather than inductive reactance; the input cable should be connected to the plate of the tube and the "*Gnd.*" lead to ground in order to take the audio voltage off this resistor.

ALIGNMENT OF RADIO-FREQUENCY STAGES—The equipment used for r-f alignment is identical to that for i-f alignment, except that the test oscillator output is connected to the antenna lead of the receiver, and different frequencies are employed.

FREQUENCY MEASUREMENTS—In using the oscillograph for frequency measurement, either Lissajou figures (sine waves on both axes) may be used, or the linear timing axis may be employed on the horizontal axis. The most flexible method for frequencies up to 100,000 cycles is the linear timing axis method. The frequency stability of the saw-tooth oscillator running free is not good enough to depend upon for accurate measurements, but when this oscillator is synchronized with a standard-frequency voltage, its frequency stability is the same as that of the standard, and it can be synchronized at any sub-multiple of the standard frequency down to about one-tenth. This allows convenient calibration of a device at many points between one-hundredth of—and ten times a single standard-frequency source, and every point is as accurate as the standard. If a 1000-cycle standard source is used, calibration points between 10 and 10,000 cycles are easily obtained. Using Lissajou figures, calibration points between 100 and 10,000 cycles can be obtained. A frequency standard which is almost universally available is the 60-cycle a-c supply. Since the advent and rapid spread of electric clocks, the frequency of nearly all commercial power is held to a very close tolerance. This allows accurate calibration at frequencies up to about 600 cycles. "*Sync.*" switch S-4 reverses the input to the saw-tooth oscillator and in so doing provides synchronization with impulses of opposite polarity.

CHECKING PHASE SHIFT—To check phase shift of electrical equipment with the oscillograph, observe the screen pattern with the input to the equipment connected to the "*Horizontal*" jacks and the output from the equipment connected to the input cable. If no phase shift exists, a sloping straight-line image will appear. The internal amplifiers in the oscillograph introduce some phase displacement which must be considered.

CIRCUITS

The schematic arrangement of the entire circuit is shown in Figure 32.

An amplifier consisting of two stages constitutes the means of obtaining gain for the signal applied to the vertical deflecting system. The input to this stage is a high-resistance step attenuator connected to provide stepped gain control. An isolation capacitor is made a part of the input circuit

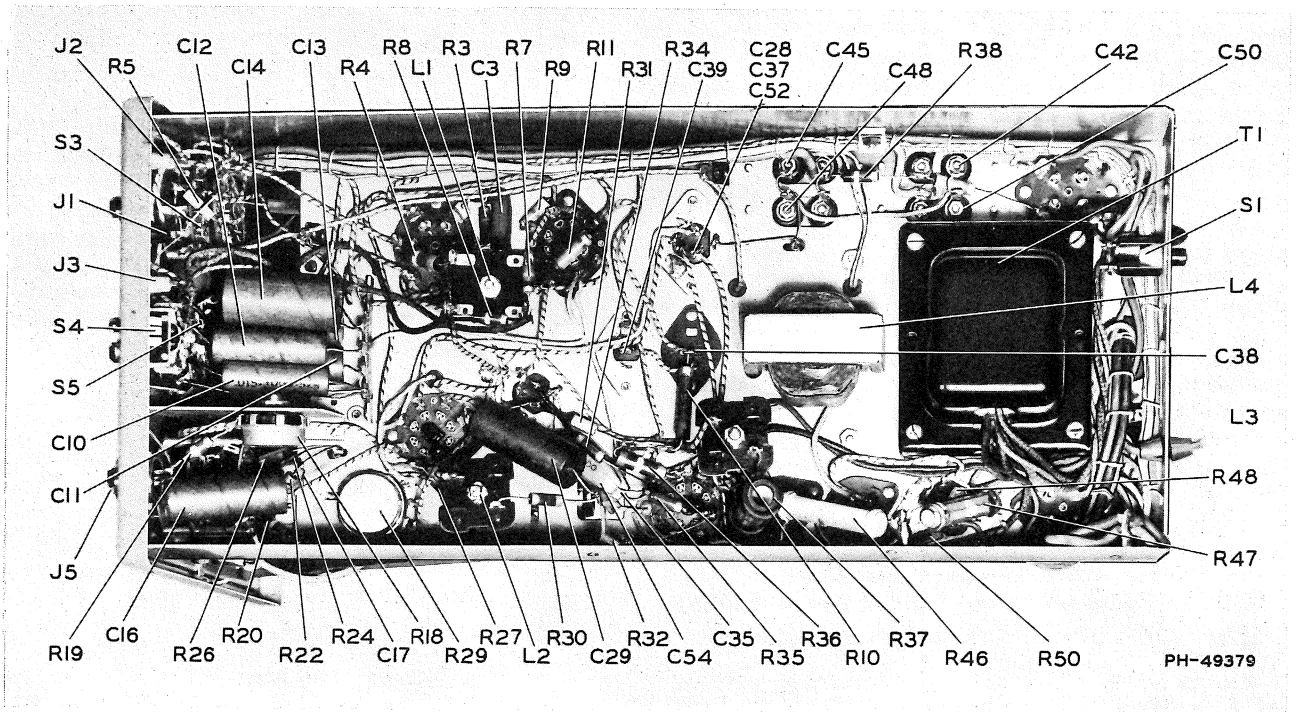


Figure 35—Bottom View of Chassis

to exclude from the grid any direct current which may be associated with the circuit being observed. The plate, or output tube (RCA-1852) is composed of two elements in series, a resistor and an inductance whose values are so designed as to effect a broad and uniform frequency response in the amplifier stage. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor.

The amplifier for the signal applied to the horizontal deflecting plates is a single stage. A switch is provided to disconnect the Horizontal Amplifier, thereby applying the voltage to be studied directly to the deflecting plate. Extra contacts are used on the input switch to the horizontal amplifier for feeding in the timing or "saw-tooth" oscillator signal.

A synchronization system is included, as shown in the input circuit of the RCA-884. This is included in the Horizontal Amplifier switch and is described under "Operation." The timing axis oscillator stage, using the RCA-884, is designed to have a frequency range of approximately 4-22,000 cycles, controlled through the "*Range*" switch and "*Frequency*" control. The signal from this oscillator has a "saw-tooth" wave shape, obtained as follows: A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the RCA-884 tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the tube ionizes) is reached. When the RCA-884 ionizes, the capacitor is short-circuited and the voltage across it drops nearly to zero. The tube immediately deionizes and allows the capacitor to start charging again. In this manner, the voltage across the capacitor has a "saw-tooth" characteristic. The capacitor referred to above is selected by the position of the "*Range*" switch as described in "Operation." With the "*Horizontal Amplifier*" switch on "*Timing,*" the voltage across this capacitor passes through the horizontal amplifier to the plates of the cathode-ray tube. The operation of the "*Sync.*" control, in the grid circuit of the RCA-884 is described under "Operation."

The cathode-ray tube has previously been described under "General Discussion of Cathode-Ray Tube." Controls used to alter the intensity, focus and zero adjustments are described under "Operation."

Power required for operation of the instrument is obtained through the power unit from a 110- to 120-volt, 50- to 60-cycle supply. Voltage rectification is accomplished by one RCA-80 and one RCA-879 rectifier tube, one being used full-wave and the other half-wave. One of these tubes supplies plate voltages for the amplifier stages and sweep oscillator, filtered through a reactor-capacitor combination. The other supplies the high voltage to the cathode-ray tube for polarization purposes.

MAINTENANCE

Under ordinary circumstances no adjustments need be made on the instrument but if these are disturbed they can be readjusted only with the use of square wave inputs obtained from a reliable square generator. Normally this means returning the instrument to the factory.

Radiotrons

Under ordinary usage within the ratings specified for voltage supply, tube life will be consistent with that obtained in other applications. The amplifier, oscillator and rectifier tubes will wear in accordance with loss of emission; whereas the determining factor in the life of the cathode-ray tube is the deterioration of the fluorescent screen. It is therefore advisable to avoid leaving a bright, concentrated "spot" on the screen. Also, the image of the phenomena under observation should be removed from the screen when not actually being studied or measured; this item of care will enable a long and useful life to be obtained from the tube.

It is ordinarily not possible to test the Radiotrons in their respective sockets, due to the likelihood of circuit effects causing error. Their removal and check with standard tube-testing apparatus is therefore desirable. Replacement of the questionable tube with one known to be in good condition is another aceptable and definite means of tracing tube troubles.

On the cathode-ray tube, excessive wear and approach to its limit of life is indicated by inability to obtain a satisfactory focus, and also by the screen becoming streaked and spotted. When it becomes necessary to install a new cathode-ray tube, some rotational adjustment may be required to bring the axes of deflection into their proper horizontal and vertical planes. This is accomplished by loosening the screw on the cathode-ray tube shield clamp, rotating the socket as desired, and then tightening the screw.

Fuse Replacements

A small 1½-ampere cartridge fuse is used in the primary circuit of the power transformer. This fuse is intended for protection of the entire power system of the oscillograph, and, therefore, should not be replaced by one having a higher rating, nor be shorted out. A fuse failure should be carefully investigated before making a replacement, since with fuses of accepted quality, there usually will be a definite cause for the breakdown. The cause may originate from a surge in the power-supply line, but the greater percentage of causes may be centered in the apparatus protected, such as shorted rectifier elements, and so forth. Occasion-

ally, a fuse may open from heat generated at one of its clip contacts. These points should therefore be kept clean and in secure contact with the fuse.

Resistance and Continuity Tests

The chassis wiring layout giving color code and physical relation of the parts is shown in Figure 33. All resistor and capacitor values are given to facilitate a rapid and sure test for continuity of circuit and the condition of same. Coils and transformer windings have their d-c resistances shown.

In working on the chassis of the oscillograph, care must be observed to have the power supply completely disconnected. The high voltages associated with the circuits of the cathode-ray tube make it especially dangerous to attempt to handle or work on the chassis while the power is "On."

Care should be exercised in replacing any part that may be found faulty. All wiring associated with the part involved must be removed, and especial attention given to the possibility of damage to other wiring or parts. The relation of wiring and parts should be the same as in the original assembly. The insulation and spacing of the high-voltage leads is very necessary and an important item to be adhered to in servicing of the instrument.

Voltage Measurements

One means of learning the condition of operation and tracing the circuit faults of the oscillograph is by checking the values of the voltages and currents at the Radiotron sockets. The normal values, which can be expected to be found when the instrument is working properly under the specified power rating, are indicated by the Radiotron Socket Voltage Table. In general, the values shown are measured from the socket contacts to ground; however, the heater or filament voltages are a-c and appear between the F-F or H-H clips. All readings given are actual operating values, and do not allow for any errors likely to be caused by current drain of the measuring instrument. Some of the voltages are not measurable with ordinary test equipment; these have been asterisked in the table.

TUBE SOCKET VOLTAGES

Voltages to ground: 20,000 ohms/volt voltmeter. 115 volts applied to primary.

			Stock #158
RCA-879	Plate to ground		—1480
RCA-879	Fil. to ground		AC1190
RCA-80	Plate to ground		AC435
RCA-80	Fil. to ground		+540
RCA-1802	Fil.		—1320
RCA-1802	Grid		—1360 to —1275
RCA-1802	1st Anode		—970 to —1160
RCA-1802	Def. Plate #		+60 to —100
RCA-1802	Def. Plate #		+75 to —85
RCA-1852	Plate		+260
RCA-1852	S 6		+150
RCA-1852	K		+2.25
RCA-1852	Sup.		0
RCA-6C6	2nd Stage	P	
RCA-6C6	2nd Stage	SG	
RCA-6C6	2nd Stage	K	
RCA-6C6	2nd Stage	Sup.	
RCA-6SJ7		P	+210
		SG	+75
		K	+2.8
		Sup.	+2.65
RCA-6C6	1st Stage	P	
RCA-6C6	1st Stage	SG	
		K	
		Sup.	
RCA-6C6	Horiz.	P	+212
	Amp.	SG	+95
		K	+2.8
		Sup.	0
RCA-884		P	+53
		K	+7 to 8

REPLACEMENT PARTS

Insist on genuine factory-tested parts, which are readily identified and may be purchased from authorized dealers.

STOCK No.	DESCRIPTION	Unit List Price
33873	Cable—Input cable complete	$18.00
12814	Capacitor—5.6 mmfd. (C1, C18, C22, C26)	.35
14079	Capacitor—6.8 mmfd. (C19, C21)	.35
13001	Capacitor—8.2 mmfd. (C25)	.35
12948	Capacitor—33 mmfd. (C15)	.35
12813	Capacitor—82 mmfd. (C6, C23)	.35
13894	Capacitor—390 mmfd. (C7)	.35
12537	Capacitor—560 mmfd. (C17)	.35
13054	Capacitor—1,200 mmfd. (C8)	.50
4881	Capacitor—3,300 mmfd. (C3, C9, C35)	.60
30856	Capacitor—.015 mfd. (C10)	.90
30857	Capacitor—.035 mfd. (C11)	.90
30848	Capacitor—0.1 mfd. (C12)	.90
18000	Capacitor—0.1 mfd., 1,250 volts (C42, C45, C48, C50)	xx
30849	Capacitor—0.25 mfd. (C4, C14, C36)	1.05
30860	Capacitor—0.5 mfd. (C16, C40, C41, C53)	.90
18416	Capacitor—1 mfd. (C2, C13, C29, C30, C31, C32)	1.00
33879	Capacitor—10 mfd., 300 volts (C38, C39, C44, C47)	.90
33880	Capacitor—10 mfd., 300 volts, 10 mfd., 300 volts, 10 mfd., 150 volts, 20 mfd., 25 volts (C43, C46, C49, C51)	2.00
33865	Capacitor—10 mfd., 450 volts, 10 mfd., 450 volts, 40 mfd., 25 volts (C5, C33, C34)	1.80
33159	Capacitor—250 mfd., 15 volts, 10 mfd., 350 volts, 10 mfd., 150 volts (C28, C52, C37)	1.60
12477	Choke—Filter reactor (L4)	2.35
33881	Choke—Horizontal amplifier plate choke (L1)	1.80
33867	Choke—Vertical amplifier plate choke (L2, L3)	2.40
11859	Condenser—3 to 30 mmfd., variable condenser (C27)	.25
33866	Condenser—60 to 120 mmfd., variable condenser (C20, C24)	.35
33870	Connector—Input cable connector (J5)	1.00
33874	Control—1,000 ohms—synchronizing control (R6)	1.00
17694	Control—10,000 ohms—low frequency compensating control (R29)	xx
33861	Control—10,000 ohms—vertical gain control (R33)	1.75
13984	Control—50,000 ohms—compensating control (R18)	1.00
33863	Control—50,000 ohms—intensity control and power switch (R41)	3.60
33864	Control—250,000 ohms—focus control (R43)	3.60
33859	Control — 500,000 ohms — horizontal gain control or centering control (R2, R51, R52)	1.00
33860	Control—2 meg.—frequency control (Fine) (R12)	1.60
33872	Escutcheon—Front panel escutcheon	1.70
30926	Foot—Elastic foot for case	.10
14133	Fuse—1 ampere line fuse (F1)	.18
30925	Handle—Carrying handle for case	1.75
33891	Jack—Black pin jack (J1, J4)	.20
33890	Jack—Red pin jack (J2, J3)	.20
32116	Knob—Control knob	.30
13210	Mounting—Fuse mounting strip	.30
13428	Resistor—150 ohms, 1/4 watt (R35)	.20
12261	Resistor—390 ohms, 1/4 watt (R9)	.20
30546	Resistor—470 ohms, 1/4 watt (R5)	.20
12414	Resistor—560 ohms, 1/4 watt (R34)	.20
14076	Resistor—820 ohms, 1/4 watt (R27)	.20
14720	Resistor—1,000 ohms, 1/4 watt (R3)	.20
12267	Resistor—1,200 ohms, 1/4 watt (R49)	.20
6134	Resistor—1,200 ohms, 1 watt (R10)	.22
13716	Resistor—2,200 ohms, 1/4 watt (R32)	.20
13714	Resistor—5,600 ohms, 1/4 watt (R30)	.20
14559	Resistor—10,000 ohms, 1/4 watt (R7, R17, R20)	.20
3219	Resistor—18,000 ohms, 1/2 watt (R48)	.20
33862	Resistor—18,000 ohms, 20 watt (R37)	1.70
30409	Resistor—27,000 ohms, 1/2 watt (R11, R38)	.20
14167	Resistor—27,000 ohms, 2 watt (R47)	.25
12454	Resistor—33,000 ohms, 1/4 watt (R31)	.20
12487	Resistor—33,000 ohms, 2 watt (R46)	.25
6143	Resistor—43,000 ohms, 1/4 watt (R22)	.20
14560	Resistor—100,000 ohms, 1/4 watt (R8, R19)	.20
3252	Resistor—100,000 ohms, 1/2 watt (R28, R39)	.20
30154	Resistor—100,000 ohms, 1 watt (R4)	.22
13483	Resistor—120,000 ohms, 1 watt (R36)	.22
11676	Resistor—200,000 ohms, 1/4 watt (R24)	.20
14583	Resistor—220,000 ohms, 1/2 watt (R42)	.20
30784	Resistor—330,000 ohms, 1/2 watt (R14, R50)	.20
12285	Resistor—470,000 ohms, 1/4 watt (R13, R40)	.20
18020	Resistor—470,000 ohms, 1 watt (R44, R45)	.22
30963	Resistor—820,000 ohms, 1/4 watt (R25)	.20
13730	Resistor—1 meg., 1/4 watt (R23, R26)	.20
30652	Resistor—1 meg., 1/2 watt (R1, R21)	.20
12201	Resistor—1.5 meg., 1/4 watt (R15, R16)	.20
33871	Screen—Calibration screen for Cathode Ray Tube	1.30
31769	Socket—4-contact tube socket	.30
18351	Socket—6-contact tube socket	xx
18467	Socket—8-prong octal tube socket	.25
33001	Socket—11-prong magnal socket for Cathode Ray Tube	1.20
33886	Switch—Horizontal amplifier switch (S3)	2.00
33887	Switch—Range switch (S5)	1.50
33885	Switch—Safety interlock switch (S1)	1.10
33868	Switch—Sync switch (S4)	1.40
33869	Switch — Vertical amplifier switch (S6)	1.90
33884	Transformer—105-125 V, 60 cycle power transformer (T1)	10.50
14119	Transformer — Synchronizing transformer (T2)	3.05

xx Price upon application to your RCA Parts Distributor.
All prices are subject to change or withdrawal without notice.

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